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(54) Process for lost foam casting of aluminium with coated pattern

(57) In the lost foam casting of aluminum coating a fugitive pattern with a refractory coating containing an acid-gasifiable (e.g. $CaCO_3$) compound, and contacting the casting with the coating thereon with an acid to dissociate and gasify the compound and rupture the coating.

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Description

TECHNICAL FIELD

[0001] This invention relates to the lost foam process for making aluminum castings and more specifically to coating the lost foam pattern with a refractory coating that is readily removable from the aluminum casting.

BACKGROUND OF THE INVENTION

[0002] The "lost foam" process is well known in the art, and involves principally the steps of: (1) preparing (e.g. molding) a pattern from a fugitive material such as expanded polystyrene [EPS]; (2) coating the pattern with a refractory coating (i.e. about 0.25 mm to about 1.5 mm thick) to stiffen the pattern, provide a barrier between the surface of the pattern and the sand, and control the metal fill rate; (3) drying the coating; (4) investing the pattern in a bed of unbonded sand to form a mold about the pattern; (5) pouring molten aluminum into the mold to vaporize the pattern and form a casting that replicates the shape of the pattern; and (6) removing the sand from around the casting. The casting may or may not be water quenched in the course of a heat treatment following casting depending on the particular aluminum alloy used and the desired final microstructure. For example, A319 aluminum alloys are frequently quenched in water in the course of a T-5 heat treatment to improve its machineability and dimensional stability.

[0003] EPS pattern coatings typically comprise water-based slurries (i.e. about 45% - 70% by weight solids) including various combinations of (1) refractories such as silica, alumina, chromite, mica, zircon, quartz, olivine, aluminosilicates or hollow glass microspheres, (2) binders such as clay and various polymers, (3) surfactants, (4) thixotropic agents, and (5) dispersants. On a dry basis, the coatings comprise about 80% to about 98% by weight refractory, about 0.5-18% by weight binders, and about 2% by weight surfactants/dispersants/and thixotropic agents. The permeability of the coating is controlled by the size and shape of the refractory particles, and serves to control the rate at which liquid and gaseous pyrolysis products escape into the sand which, in turn, controls the rate at which the aluminum enters the mold. The coatings are most commonly applied by dipping the pattern therein but may also be sprayed, brushed or pumped onto the pattern. Though water is the most common carrier for the refractories, other carriers that are compatible (e.g. a non-solvent) with the pattern may also be used.

[0004] Unfortunately, the refractory coating that is applied to the foam pattern adheres to the surface of the aluminum casting, and is difficult, time consuming and expensive to remove. This is particularly the case where the coating needs to be removed from the internal passages of complex castings such as internal combustion engine blocks or heads. Some known techniques for removing at least a portion of the coating include (1) thermally shocking the coating by plunging the hot casting into water immediately after casting, (2) shot blasting the casting (e.g. with plastic or ceramic shot), (3) scrubbing the casting in an agitated aqueous slurry of abrasive particles, (4) rapping the casting with a hammer(s), (5) immersing the casting in a bath of ultrasonically agitated water, (6) blasting the casting with a stream of water or steam, and (7) dipping the casting in a bath of molten salt.

SUMMARY OF THE INVENTION

[0005] The present invention is a simple process for readily and economically removing any of the pattern's refractory coating that adheres to an aluminum lost foam casting following removal of the sand. The invention is particularly advantageous in that it permits removal of the coating in areas of the casting (e.g. internal passages) inaccessible to traditional mechanical means for removing the coating. The invention contemplates coating the foam pattern with a refractory coating containing an acid-gasifiable compound that is thermally stable (i.e. won't decompose) at the casting temperature, and following casting, contacting (e.g. dipping, spraying, etc.) the coated casting with an inorganic or organic acid washing solution to dissociate the compound into a plethora of gas bubbles that effervesce and rupture the coating to facilitate its removal. The thermally stable, acid-gasifiable compound will preferably comprise an inorganic carbonate, more preferably an alkali metal carbonate (i.e. calcium, sodium, potassium and lithium carbonate) and most preferably calcium carbonate. Such carbonates are inexpensive and form soluble byproducts with the acid's anion, which further facilitates removal from the casting. The most preferred compound is calcium carbonate which is insoluble in the carrier for the refractory and deposits as a solid directly from the slurry onto the pattern. The calcium carbonate will preferably be used in concentrations of about 20% by weight in the coating, on a dry basis. The particle size of the calcium carbonate can thus be controlled and used as a means to control the speed/aggressiveness of the reaction. Calcium carbonate will preferably have a particle size less than about 5 microns to provide a large reaction surface for a very aggressive reaction. Soluble carbonates such as sodium, potassium and lithium carbonate may also be used, though at least some of these carbonates will dissolve in the water carrier for the refractory. The soluble carbonates will precipitate out of the carrier when the coating is dried.

[0006] Preferably the casting will be immersed in a bath of the acid. In one embodiment, the acid treatment is for the

sole purpose of removing the coating and the treatment may be done while the casting is either hot or cold. In another embodiment, i.e. where the casting needs to be quenched anyway as part of a heat treating operation, the quenchant (e.g. water) will be acidified such that coating removal is achieved at the same time that the hot casting is being quenched.

[0007] Virtually any acid may be used so long as it does not attack the surface of the casting, and may include weak acids such as acetic acid, or diluted strong acids such as phosphoric or hydrochloric acid, *inter alia*. Dilute phosphoric acid is preferred as it is less corrosive of surrounding equipment than many other acids, and yet is just as effective in removing the coating. Dissociation of the gasifiable compound is more rapid with the stronger acids than with the weaker acids. The acid will preferably have a pH less than about 2.5 for rapid dissociation of the compound and more aggressive rupture of the coating.

DESCRIPTION OF A PREFERRED EMBODIMENT

[0008] The invention will better be understood when considered in the light of the following detailed description of certain aspects thereof provided hereafter in connection with the preferred gasifiable additive, $CaCO_3$.

[0009] The refractory coatings of the present invention will preferably comprise about 15% to about 25% or more by weight dry of calcium carbonate. Below about 15%, there is insufficient carbonate for rapid, effective removal of the coating. Above about 25% by weight, no significant additional benefits are observed, and an undesirable displacement of the refractory component of the coating occurs. The precise concentration of the gasifiable compound in the coating for any given situation will depend on which compound, which acid, and which acid concentration is used and can be determined by routine experimentation. The same is true for the concentration of the acid, which tests have shown can vary from concentrated to very dilute (i.e. as much as 100 parts water to 1 part acid).

[0010] A number of tests were conducted to demonstrate various aspects of the invention the invention. 100 mesh wire screens were cut into test wafers 2 and 9/16 inch in diameter. The wafers were (1) dipped into several different coating slurries, (2) dried at 200 °F for 90 minutes, and (3) weighed. The slurries comprised mica-based commercial coatings from the Borden and Ashland companies (1) without a calcium carbonate addition, and (2) with the addition of ground up limestone (i.e. calcium carbonate) containing a small amount (i.e. about 1.5±%) of magnesium carbonate. In one series of tests, the dried coatings contained 20% by weight of the limestone. In other tests, different limestone concentrations were used. Some of the dried samples were also baked at 932°F for 30 minutes to simulate the thermal conditions experienced during aluminum casting, and weighed again. The permeability of the baked and unbaked screens coated with the 20% $CaCO_3$ coating was then measured using a conventional foundry electric or floating drum perimeter such as described in "Innovations in Controlling the Lost Foam", Modern Casting, January 1996. Table I shows the results of those tests, to wit that with coatings containing 20% by weight calcium carbonate, the permeabilities are unchanged as between the baked and unbaked samples.

TABLE I

Permeability of screens (in AFS permeability units)		
	Dried	**Baked at 500°C**
Coating without additive	4.9	7.0
Coating with 20% additive	4.9	6.9

Samples of the same 20% CaCO3-containing coated screens were then dipped in various wash solutions for 0.5 to 1 minute, dried and weighed. In the samples having the CaCO3-containing coatings, vigorous bubbling occurred that disrupted the integrity of the coating. Table II shows the results of one such test, and specifically that, on a basis of the percentage of the original coating removed, a coating containing 20% by weight calcium carbonate was removed 18 times more effectively when dipped in a dilute phosphoric (i.e. 1 part H_3PO_4 to 25 parts H_2O) wash solution than a coating containing no carbonate and dipped in the same wash solution, and almost 900 times more effectively than a carbonate-free coating dipped in a non-acidic wash solution.

TABLE II

Percent (by dry weight) of coating residue removed by wash step		
	Water wash	Acid wash (1:25 phosphoric acid)
Coating alone	0.1	4.9
Coating + carbonate material (added 20% of dry weight	0.1	88.7

Table III shows the percent of the 20% $CaCO_3$ -containing coating removed from the screens in phosphoric acid wash solutions having different H_3PO_4 concentrations. The data shows that 89% or more of the $CaCO_3$-containing coatings was removed with very dilute and concentrated wash solutions while only about 20% of the carbonate-free coatings were removed with only the most concentrated acid wash solutions.

TABLE III

Percent (by dry weight) of coating residue removal using different acid strengths		
Phosphoric acid dilution	Coating alone	Coating + carbonate material (added as 20% of dry weight)
Concentrated	20+	99+
1:10	20	93
1:25	NA	92
1:50	14	91
1:100	6	89

[0011] In another series of tests the concentration of the $CaCO_3$ and the acid in the wash was varied. Table IV shows the effects of various concentrations of the carbonate in an acid-free wash, a wash containing 1 part H_3PO_4 to 25 parts H_2O, and a wash containing 1 part H_3PO_4 to 50 parts H_2O. That data shows that an acid-free wash has no effect on the coatings while significantly more of the coating is removed in the acid wash at calcium carbonate concentrations near 20% than at concentrations near 10% or less.

TABLE IV

Percent (by dry weight) of coating residue removal using various carbonate concentrations			
% of solids as carbonates	Water wash	Acid wash (1:25 phosphoric acid)	Acid wash (1:50 phosphoric acid)
5%	0	58	21
10%	0	59	40
20%	0	92	91

[0012] While the invention has been disclosed in terms of certain specific embodiments thereof, it is not intended to be limited thereto but rather only to the extent set forth hereafter in the claims which follow.

Claims

1. In the process for the lost foam casting of aluminum comprising the principle step of forming a pattern from a polymeric foam, depositing a refractory coating on the surface of said pattern, embedding said pattern in a bed of sand that forms a mold about said pattern, pouring molten aluminum into said mold to vaporize and displace said pattern, replicate said pattern with said aluminum and coat said aluminum with said coating, allowing said aluminum to solidify into a casting, and removing said sand from said casting, the improvement comprising said coating comprising a sufficient amount of a thermally stable, acid-gasifiable compound to rupture said coating upon gasification, and contacting said coating with an acid to dissociate and gasify said compound and rupture said coating.

2. The process according to claim 1 wherein said gasifiable compound is selected from the group consisting of alkali metal carbonates.

3. The process according to claim 2 wherein said alkali metal carbonate is calcium carbonate.

4. The process according to claim 3 wherein said calcium carbonate has an average particle size less than about 5 microns.

5. The process according to claim 3 wherein said calcium carbonate comprises about 15% by weight to about 25% by weight of said coating.

6. The process according to claim 1 wherein, while hot, said casting is quenched in an acidic aqueous quenchant.

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EUROPEAN SEARCH REPORT

Application Number
EP 98 20 2581

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	US 4 281 705 A (JENEY TIBOR) 4 August 1981 * claims 1,2 *	1-6	B22C3/00 B22C7/02 B22D29/00 B22D31/00
Y	PATENT ABSTRACTS OF JAPAN vol. 013, no. 100 (M-805), 9 March 1989 & JP 63 290647 A (OKAZAKI KOUSANBUTSU KK), 28 November 1988 * abstract *	1-6	
Y	US 5 387 280 A (KENNERKNECHT STEVEN) 7 February 1995 * column 4, line 6-13 *	1-6	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

B22C
B22D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	8 December 1998	WOUDENBERG, S

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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